Final Report to the Nova Scotia Habitat Conservation Fund: Determining the role of food availability on swallow population declines

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Background

In the past 40 years, Breeding Bird Surveys documented declines in most species of aerial insectivores (birds that feed in the air, on flying insects) such as swallows, swifts, nightjars and flycatchers (Nebel et al. 2010). These declines are most severe for populations in northeastern North America (Nebel et al. 2010), including Nova Scotia. Although the reason for these declines is unknown, several explanations have been suggested. The leading explanation suggests that declines relate to decreases in aerial insects, the common food source for this group of birds, and/or a mistiming between peak breeding and insect prey availability.

In 2014, we examined the role of aerial insect abundance on reproductive success and the timing of breeding activities Bank, Barn, Cliff and Tree Swallows in Nova Scotia (NS) and New Brunswick (NB). This project had three main objectives:

1. Determine the relationship between daily insect abundance and the timing of breeding (i.e., clutch initiation and hatching dates) and reproduction success (i.e., clutch size, hatching success and nestling survival) for all four species of swallows;
2. Determine the relationship between insect abundance during nestling development and nestling body condition for Barn, Cliff and Tree Swallows; and,
3. Determine if the timing of breeding has changed over the last 50 years through examining long-term data and if changes are correlated with climate.

Below, we present the methods used to address these objectives, our preliminary results and next steps in this multi-year project.

Methods

Data collection

We collected 653 insect samples using stationary tow nets (Hussell and Quinney 1987) at four sites throughout the breeding season. Insects were identified to order or suborder (Diptera only), grouped into size categories (e.g., 3-5 mm, 5-7 mm, etc.) and dry sample mass was recorded.

We monitored 71 Bank, 66 Barn, 91 Cliff and 95 Tree Swallow nests every 2-3 days during the breeding season. From these frequent checks, we were able to determine the timing of breeding (i.e., clutch initiation and hatching dates) and the breeding success (i.e., clutch size, brood size and chick survival to day 12.

We also banded 226 Barn, 103 Cliff and 367 Tree Swallow nestlings at day 9, 10 and 12, respectively. Due to nest structure, we were unable to band Bank Swallow nestlings. At the time of banding, we collected morphological measurements from the young, including mass, tarsus length and head-bill length. These measurements were used to calculate an index of body condition.

Finally, we compiled long-term data from the Maritime Nest Records Scheme (all species; 1961-present), data from Marty Leonard/Andy Horn/Sherman Boates (Tree Swallows; 1988-present) and Nat Wheelwright (Tree Swallows; 1987-present). From these data, we identified clutch initiation and hatching dates (Table 1) to determine if there were changes in the timing of breeding since the 1960s.

Data analysis

We calculated an index of daily insect abundance based on the biomass collected and the amount of time nets were open (g/h), hereafter referred to as insect abundance. Interestingly, there was not a strong relationship between insect biomass and temperature or wind speed (Pearson's $r = 0.17$ and 0.05, respectively), therefore, we did not account for these effects in our index.

We modelled the relationship between insect abundance and swallow breeding (both timing and reproductive success) for all four species. We used generalized linear models (GLMs) with a normal (for normally distributed data), poisson (for count data; e.g., clutch size) or binomial (for yes/no data; e.g., dates when nests were/were not initiated) distribution depending on the variables being examined. The models also often included variables for species, site, date, clutch/brood size and any necessary interactions when appropriate. Stepwise regressions were used to remove non-significant variables.

Examples of base models (prior to the removal of non-significant variables) used to examine the relationship between insect abundance and swallow breeding:

1. <u>Clutch initiation date</u> (CID; binomial distribution):
   Y/N nest initiated ~ Insect abundance + Species + Site + Date
2. <u>Nestling development</u> (poisson distribution):
   Insect abundance during development ~ Species:CID + Species:Site
3. <u>Nestling body condition</u> (normal distribution):
   log(body condition) ~ Insect abundance + Species + Site + Brood size + Hatching date

Finally, we examined long-term changes in CID and hatching dates using a GLM with a poisson distribution. For these models, we included annual data up to and including the median annual CID or hatching date. This approach removed second nests and focused on older individuals arriving on breeding grounds in good body condition. We also examined correlations between clutch initiation and hatching dates and spring temperature and precipitation.

Results

There was not a strong relationship between insect abundance and hatching dates, incubation period, clutch size, brood size or nestling survival to day 12. However, we found significant or near significant relationships between insect abundance and clutch initiation dates and nestling development for Barn, Cliff and Tree Swallows, so these results are presented here.

We determined the day(s) (in a seven-day window prior to the first nest being initiated and on the day the nest was initiated [day=0]) when high insect abundance was correlated with a nest being initiated 0-7 days later. The best models indicated that all species responded to insect biomass on slightly different days. Barn Swallows initiated nests 4-6 days after high insect abundance ($p<0.05$), Cliff Swallows initiated 3-6 days after high abundance ($p<0.05$), and Tree Swallows initiated 0-6 days after high abundance ($p=0.081$) (Figure 1).

We examined the relationship between insect biomass during nestling development and CID to determine if earlier CIDs were associated with a higher mean insect abundance during nestling development. For Tree and Cliff Swallows, there was a significant inverse relationship ($p<0.05$) between insect biomass and clutch initiation date, with earlier breeding birds having higher insect abundance during nestling development than later breeding birds (Figure 2). The opposite relationship was significant for Barn Swallows ($p<0.05$) with later breeding birds having higher insect abundance during the nestling stage; however, this is likely driven by one outlying observation (Figure 2).

Next, we examined the relationship between insect biomass and nestling body condition to determine if nestlings had higher body condition when insects were more abundant during development. Nestling body condition was not significantly related to insect biomass during nestling development ($p>0.05$). However, there was a significant inverse relationship between variance in body condition within a nest and insect biomass 0-2 days after the peak growth period ($p<0.05$) indicating that when insect abundance was high, there was less variability in body condition within the nest (Figure 3). The best-fit model also included species; variance in body condition for Tree Swallows was lower than Barn and Cliff Swallows ($p<0.05$; Figure 4).

Finally, we found a significant positive relationship between clutch initiation date and year for Barn, Cliff and Tree Swallows ($p<0.05$), however, there was not a significant relationship between clutch initiation date and year for Bank Swallows ($p>0.05$). Hatching dates are also significantly earlier for Barn and Tree Swallows ($p<0.05$). Together, these results indicate that three species are breeding earlier than they have in the past. Clutch initiation dates were weakly correlated with spring temperature and the strongest correlation was between the mean minimum temperature ($r = -0.42$; Figure 8). There was no relationship between hatching date and mean minimum temperature ($r = -0.14$) or with timing and precipitation (clutch initiation date: $r = -0.14$; hatching date: $r = 0.16$).

Discussion and next steps

This was the first year of a multi-year project, however, these preliminary results provide some insight into the role of food availability on swallow breeding and also long-term changes in the timing of swallow breeding.

Surprisingly, we only found strong relationships between insect abundance and CID and nestling body condition. Periods of high insect abundance prior to CID tended to result in nests being initiated a few days later. The key days prior to CID varied slightly between species (Barn: 4-6; Cliff: 3-6; and Tree: 0-6), but given that rapid egg growth starts five days prior to laying (Ward and Bryant 2006), these key periods likely provide important cues for the timing of breeding.

In addition, we found a strong relationship for Tree Swallows between CID and insect abundance during the nestling development. This suggests that pairs that breed earlier have a more abundant food supply when they are feeding young. Furthermore, nestling body condition for Barn, Cliff and Tree Swallows was less variable when insect abundance was high. This suggests that swallows may preferentially feed some young when insect abundance is low to ensure, at minimum, partial nest success. We did not find a relationship between insect abundance during the nestling development and nestling survival to day 12, indicating that insect abundance was not low enough to impact survival in the nest. However, body condition is an important predictor of survival after the young leave the nest (Naef-Daenzer et al. 2001). Therefore pairs that match CID with high insect abundance during nestling development will likely produce young that are more likely to survive after leaving the nest.

In the future, we are interesting in focusing on the relationships between CID and insect abundance during the nestling development, and the impact of insect abundance on nestling body condition. These relationships could impact individual fitness and contribute to population declines. Finally, unlike other studies have demonstrated a relationship between insect abundance (either through measuring abundance or using temperature as a proxy) and CID (e.g., Hussell and Quinney 1987, Saino et al. 2004), there is little information available on insect abundance during the nestling and the impact on nestlings.

Finally, we found that the timing of breeding has advanced for Barn, Cliff and Tree Swallows, but not for Bank Swallows. This suggests that there could be a potential mis-match between food availability and swallow breeding. In the future, we will also determine if breeding success (i.e., clutch size, hatching success and nestling survival) has also changed over this time period. The advance in CID was weakly correlated with changes in spring temperature. Future work will refine this analysis to look at regional effects and temperature during specific periods of breeding.

References

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Moller, A. P. 2013. Long-term trends in wind speed, insect abundance and ecology of an insectivorous bird. Ecosphere 4:1–11.

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Ward, S, and DM Bryant. 2006. Barn Swallows *Hirundo rustica* form eggs mainly from current food intake. Journal of Avian Biology 37: 179–189.

Table 1. Number of records used in the analysis of long-term trends in the timing of swallow breeding from the Maritime Nest Records Scheme and two Tree Swallow projects.

Species	All	Clutch initiation date	Hatching date
BANS	111	98	-
CLSW	186	175	-
BARS	621	537	225
TRES	2768	1944	1831

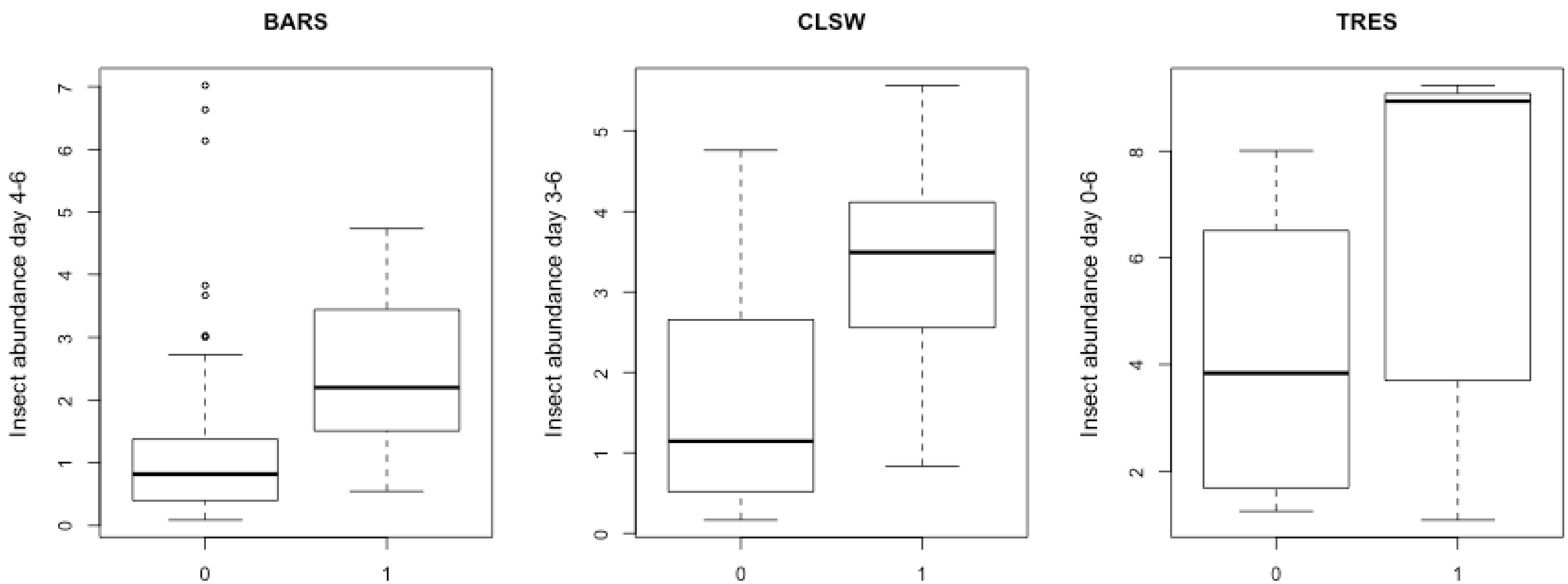

Figure 1. Relationships between insect abundance on different days prior to clutch initiation and whether or not Barn (BARS), Cliff (CLSW) and Tree Swallows (TRES) initiated nests (0 = no nests initiated and 1 = nests initiated).

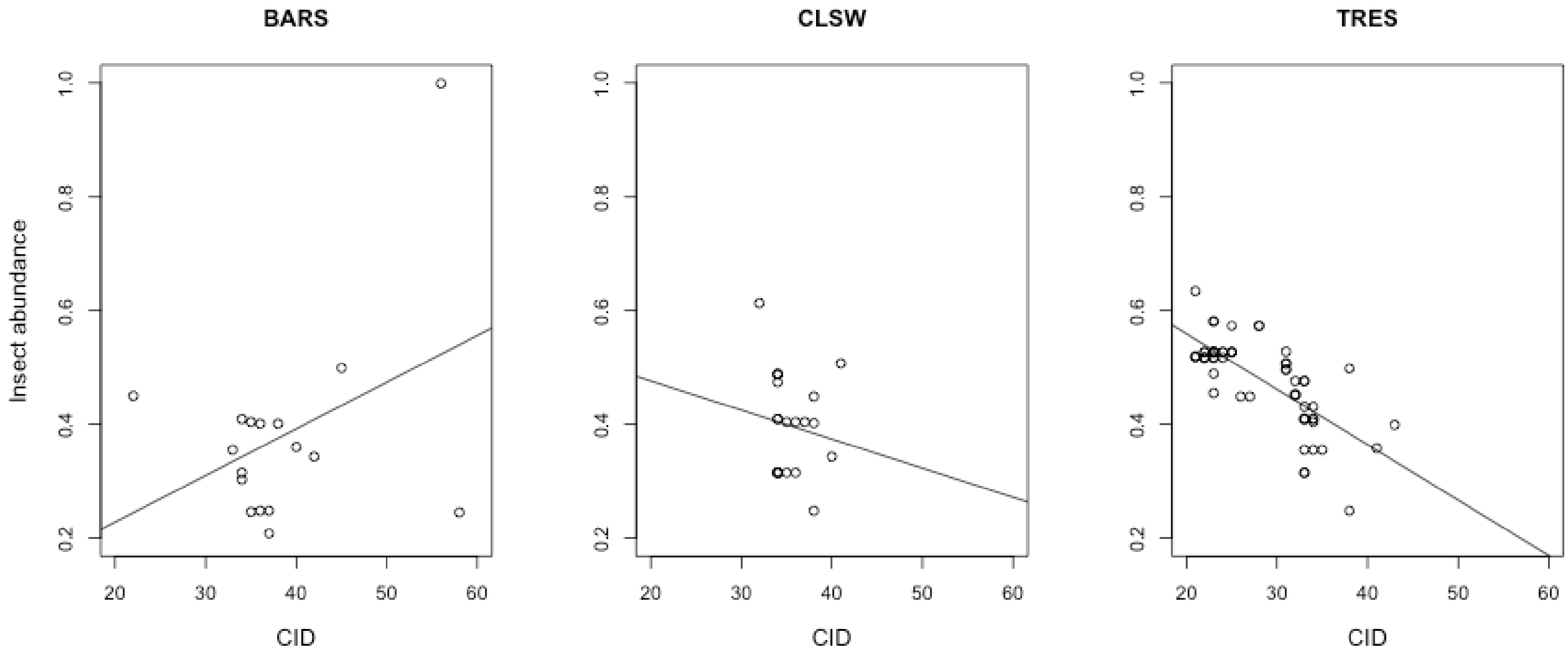

Figure 2. Relationship between mean insect biomass during nestling development and clutch initiation dates (CID) for Barn (BARS), Cliff (CLSW) and Tree Swallows (TRES).

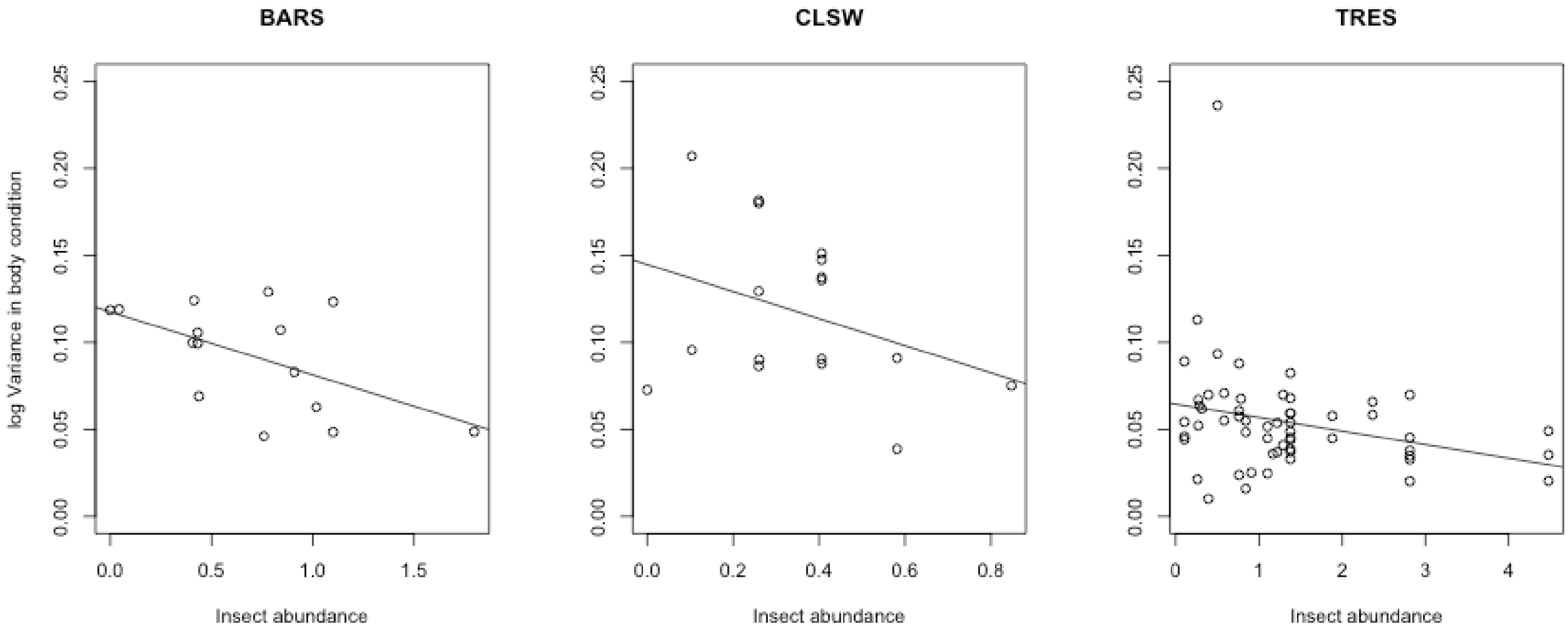

Figure 3. Relationship between variance in nestling body condition and insect abundance one day prior to banding for Barn (BARS), Cliff (CLSW) and Tree Swallows (TRES).

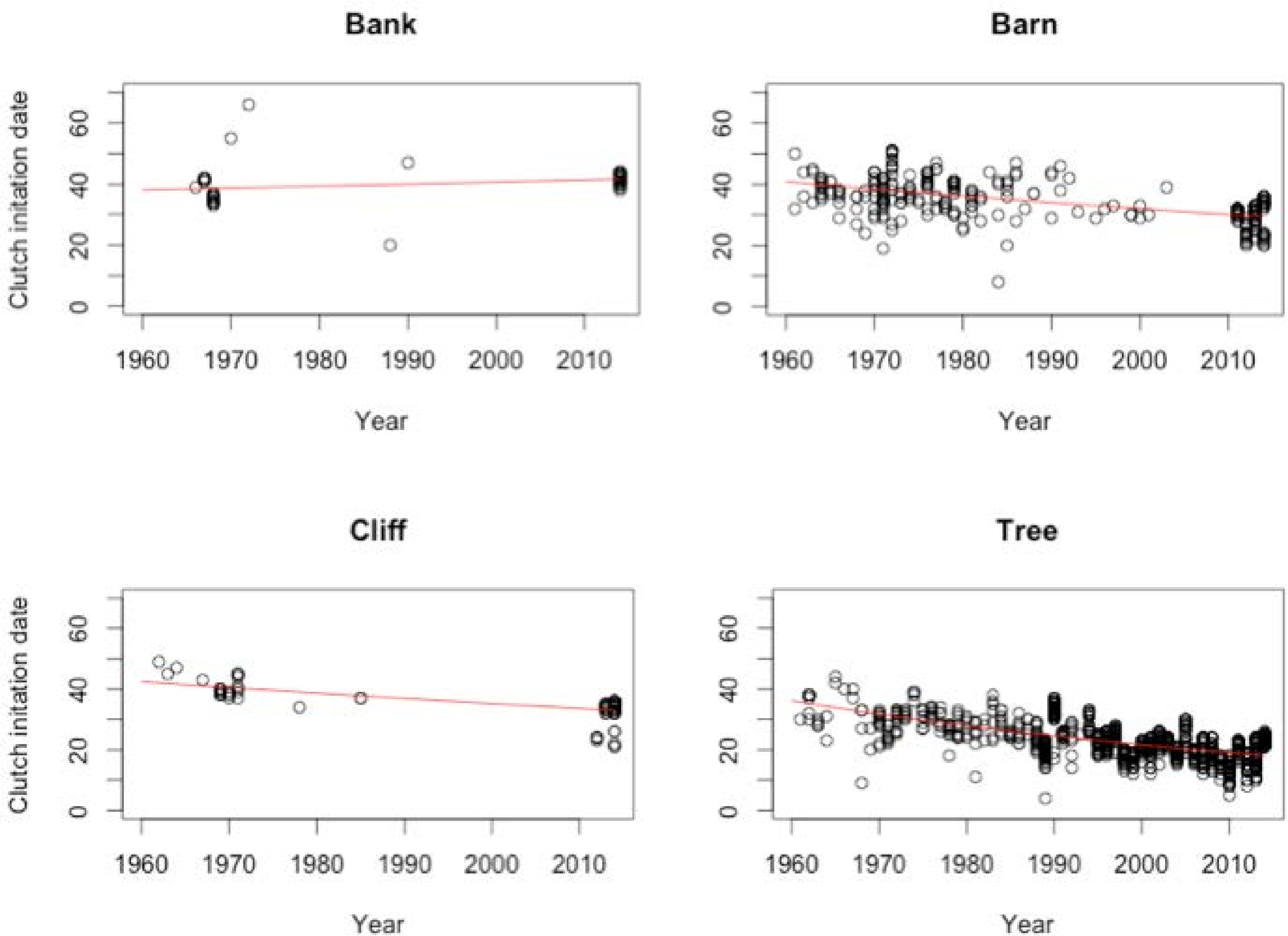

Figure 7. Relationship between clutch initiation dates and year for Bank, Barn, Cliff and Tree Swallows.

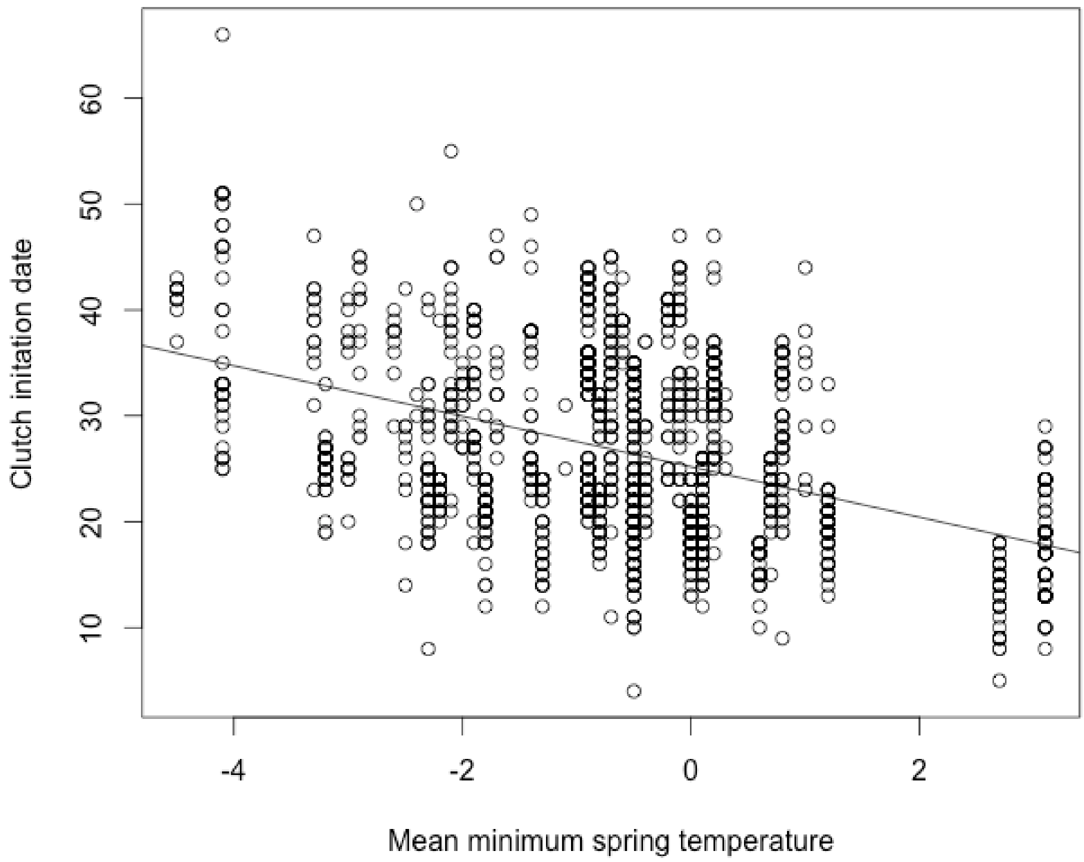

Figure 8. There was a weak relationship between mean minimum spring temperature and clutch initiation date.

Appendix I. Outreach and Communication

This project generated several opportunities for public outreach and stewardship in 2014. In addition, project results were presented at several working group meetings. All outreach, stewardship and communication activities are listed below. Support from the Nova Scotia Habitat Conservation Fund was indicated at all of these activities.

Presentations (see copies of acknowledgement slides on next page)

Aerial Insectivore meeting, Environment Canada (March 9, 2015)
LETT Symposium, Dalhousie University (March 6, 2015)
Tantramar Marsh High School (October 20, 2014)
Ontario Bank Swallow Recovery Strategy meeting (September 11, 2014)
Bird Studies Canada Atlantic annual meeting (April 23, 2014)
Northeast Swallow Working Group meeting (March 25, 2014)

Stewardship

Seven landowners and families engaged in swallow monitoring.
Tree Swallow boxes were erected on two properties (20 boxes/site) prior to the breeding season.

Media

CBC Radio 1 interview for NB Drive (July 9, 2013).
Dal News article (July 22, 2013). URL: http://www.dal.ca/news/2014/07/22/where-have-all-the-swallows-gone-.html
CBC TV interview for NB evening news (July 22, 2013). Picked up on local radio.
CBC interview for documentary program to air in Fall 2014 or Winter 2015 (July 25, 2013).
CBC TV interview for NS evening news (September 15, 2014). Picked up on local and national radio.
CBC article (September 15, 2014). URL: http://www.cbc.ca/news/canada/nova-scotia/nova-scotia-swallow-numbers-down-between-60-and-98-1.2766255
Chronicle Herald newspaper article (September 17, 2014). URL: http://thechronicleherald.ca/novascotia/1236869-researchers-seek-to-solve-puzzle-of-swallow-decline

Aerial Insectivore meeting, Environment Canada (March 9, 2015) and LETT Symposium, Dalhousie University (March 6, 2015)
"Preliminary analysis of long-term data on swallow breeding phenology"

Tantramar Marsh High School (October 20, 2014)
"Where have all the swallows gone? Using science for conservation"

Ontario Bank Swallow Recovery Strategy meeting (September 11, 2014)
"Bank Swallow research in the Maritimes"

Bird Studies Canada Atlantic annual meeting (April 23, 2014) and Northeast Swallow Working Group meeting (March 25, 2014)
"A life cycle approach to understanding population declines for swallows in the Maritimes"